Weatherwise

The Effect of Atomic Bomb Explosions on Weather

Are New England Winters Getting Milder?

The Great Storm of November, 1950

The Weather Control Bill

American Meteorological Society

Vol. 4, No. 1
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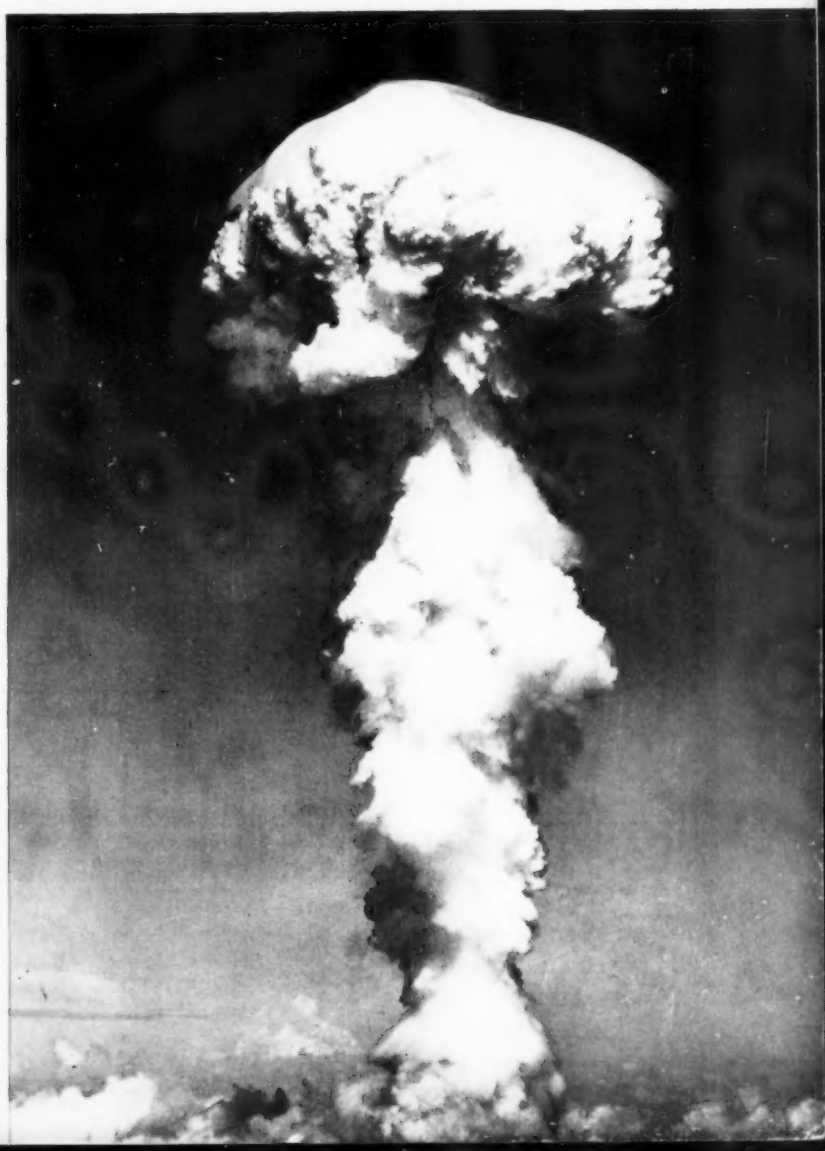

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE" — BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

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THE METEOROLOGIST AND CIVIL DEFENSE

RAPIDLY EXPANDING civil defense programs will soon require the participation of many meteorologists. Several communities have taken the lead in organizing their staffs, and weathermen are already participating in the planning of emergency services. It is expected that civil defense organizations will be set up in every sizable community and that rural county areas will also have their individual organizations.

The importance of the weather factor in military emergencies is obvious. In case of an atomic bomb explosion, the "fall-out" of contaminated matter and the consequent area made possibly dangerous by radioactive substances is largely determined by the existing wind speed and direction and lapse rate.

It should be emphasized, however, that civil defense organizations may be called on in all types of community catastrophes, not only those connected with the military situation. For more than one reason, therefore, it is essential that every civil defense group be able to call upon the theoretical knowledge as well as the practical experience of a competent meteorologist.

By means of its nationwide 24-hour vigil on the weather, the U. S. Weather Bureau will, of course, play the leading role in the meteorological phase of meeting military emergencies. The overall problem of weather and civil defense is being studied, and a general statement of policy and a handbook on the subject will soon be issued.

There are many communities, however, where the Weather Bureau does not maintain facilities. Here the individual weatherman can be of tremendous value to the authorities in charge of civil defense. This phase of the problem is being surveyed by WEATHERWISE, in co-operation with the American Meteorological Society, and a detailed discussion will be presented in a forthcoming issue of this magazine.

D. M. L.

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Cover: The top of the cloud produced by the Able Day, 1946, atomic bomb explosion in the air over the Bikini atoll in the Pacific Ocean. The mushroom head is seen rising through the 19,000-foot level. The "scarf" cloud has just formed over the top, coinciding with the freezing level in the atmosphere. Joint Army-Navy Task Force One photograph. (See page 3.)

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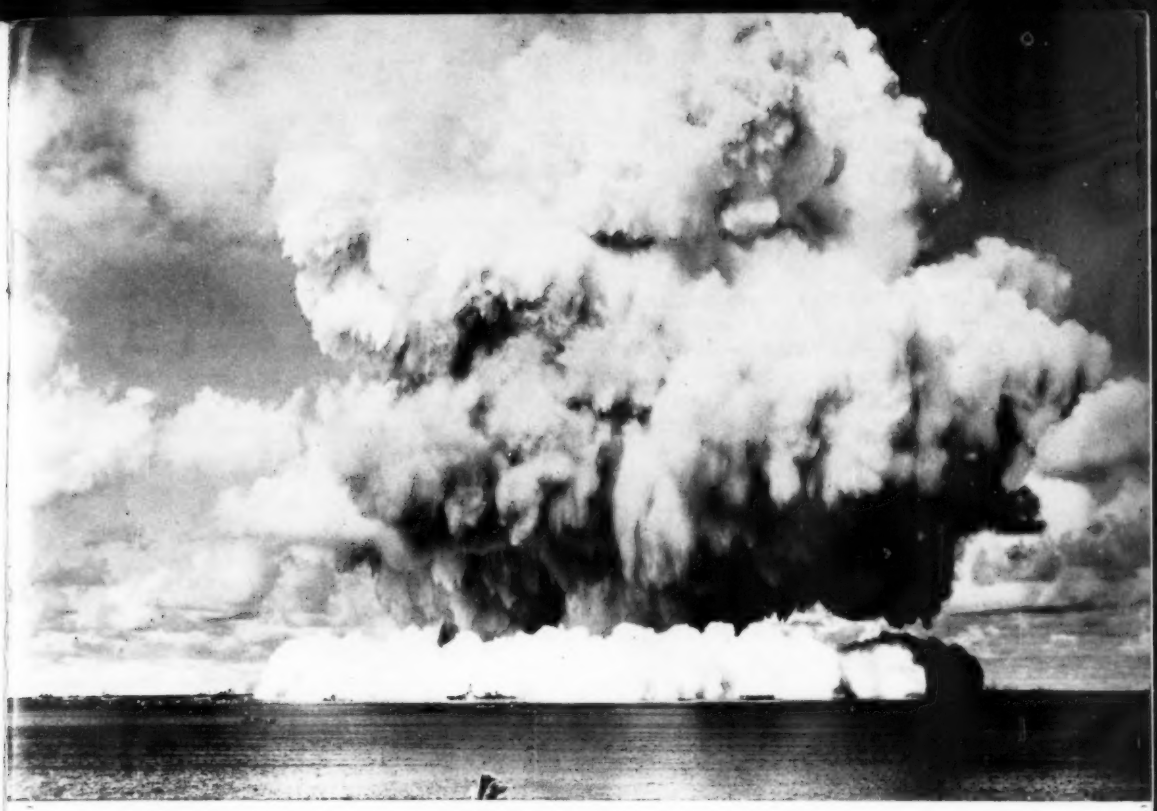


Tons of water thrown up from Bikini lagoon by the Baker Day atomic blast (underwater) shower down on the Crossroads target fleet. The gigantic base surge is seen spreading outward on the surface of the lagoon, later to rise and form an extensive stratocumulus cloud and produce vigorous rainfall in the area. The picture was taken by an automatic camera mounted in one of the Bikini towers. Joint Army-Navy Task Force One photograph.

The Effect of Atomic Bomb Explosions on Weather

BEN HOLZMAN. COLONEL. U. S. AIR FORCE

AFTER the first atomic test held in New Mexico, there was widespread speculation as to the effect of an atomic explosion on weather. There were prophecies that credited the atomic bomb with the ability easily to cause rainshowers or violent thunderstorms, the formation or destruction of hurricanes, and the generation of heat or cold waves.

Some of these fanciful speculations may have resulted, at least in part, from the dramatic newspaper accounts of the New Mexico bomb, which was exploded in a weather situation as foul as any meteorologist could imagine for such a monumental event. Rain fell in torrents, accompanied by gusty winds, lightning and thunder. With bolts of lightning flashing and darting all around, it seemed almost inevitable that a bolt would strike the bomb tower with catastrophic effect, destroying in one blinding flash the culmination of the efforts of the hundreds of scientists of the Manhattan Project.

Fortunately, in a short time the weather improved. The rain stopped. The thunder and lightning moved off to the east with the passage of a weak front over the target site. The bomb was then successfully exploded. There is no point here in describing the phenomena attendant with an atomic explosion as this has been most adequately done in

"The Effects of Atomic Weapons," published by the U. S. Government Printing Office. It is sufficient to say that all of the unusual weather occurred before the bomb was detonated. The bomb did not produce any rain or any other significant effect upon the atmosphere.

During the planning of the subsequent atomic tests at Bikini in 1946 and at Eniwetok in 1948, I was again plagued with numerous letters and admonishments to the effect that an atomic bomb exploded in these tropical air masses would really start something in the atmosphere — either a vigorous thunderstorm or an incipient typhoon. The substance of these arguments was that the large amounts of moisture in the tropical air, in addition to the large quantities of water expected to be evaporated from the immediate water areas, would be extremely conducive to storm formation. Further, many believed that the high atmospheric concentration of ionized particles resulting from the atomic burst would serve as nuclei for condensation, and thus lead to the formation of clouds and rain.

If the mechanism for producing a thunderstorm is carefully examined, it will be found that these storms require continuous updrafts from the lowest to the very high atmospheric levels. These updrafts consist of moist masses of air which are transported aloft by convection. With the existence of a proper vertical moisture structure, this convection may be caused by the heating of land areas, the lifting of an air mass by ascent over mountains or an atmospheric front. The atomic bomb is unable to produce convection of the sustained type. The atomic explosion consists of an instantaneous release of energy in which the fire ball acting like a bubble heats the surrounding air and "squirts" through the atmosphere. At any particular height, convection ceases as quickly as the hot bubble of gases passes through that level. Cooling takes place by adiabatic expansion and by mixing with the ambient air. Thus there is no similarity between a thundercloud and an atomic cloud with regard to rainmaking capabilities.

But then what about all the atomic debris and ionized particles — these should make wonderful nuclei for condensation. The answer to this is simple. Condensation or sublimation nuclei do not make it rain. Unless there is a dynamic mechanism to cause air to rise and thus become cooled to or below the dewpoint temperature no clouds or rain will result, nuclei notwithstanding. In the atomic bomb cloud there are plenty of nuclei for condensation. Even ice nuclei were present in the Bikini Able Day cloud. As the cloud top reached upward to the vicinity of 19,000 feet, a smooth lenticular cap (pileus) or "scarf cloud" formed just above the top and its drooping edges gave the appearance of cascading downward (see the front-cover picture).

One may infer from this that not even the salt of the rainmakers, silver iodide, would then have any effect on the atomic cloud. Further, in the Eniwetok tests where fairly dry air existed above 10,000 feet, the atomic bomb cloud at these levels consisted almost entirely of smoke instead of water. Even the most versatile of rainmakers would have difficulty in this case, I am certain.

About starting or destroying a hurricane with an atomic bomb — these ideas can be dismissed summarily. The forces involved in the life cycles of hurricanes are of a tremendous magnitude calling into play huge air masses of both the Northern and Southern Hemispheres. For example, to match just the kinetic energy of a moderate-sized hurricane, one would need approximately 1,000 atomic bombs. This does not consider the total energy output of a hurricane, which can be indeed colossal from the energy released in the formation of rain. A very small-sized but moderate warm front rainstorm releases energy at the rate of at least three atomic bombs per second.

The atomic bomb can, however, influence the weather in an indirect way. At Hiroshima, on the morning of August 6, 1945, an atomic bomb was exploded over the city. Scattered to broken high clouds, with some low clouds, mainly cirrus and cirrostratus with scattered cumulus, were present. A quasi-stationary front lay to the north of the city, separating a light northerly flow of winds from a southerly flow. After the explosion, flash fires broke out everywhere, and soon a large cumulonimbus cloud developed and moved to the north-northwestward. After two hours copious rains associated with thunder and lightning

(Continued on page 9)

Are New England Winters Getting Milder?

JOHN H. CONOVER, HARVARD UNIVERSITY
BLUE HILL METEOROLOGICAL OBSERVATORY

THE ANSWER to the question, "Are New England winters getting milder?" is not as simple as one might think, because the mildness or severity of a winter's weather is a combination of many meteorological variables. The most important of these are temperature, snowfall, wind speed, and sunshine. No precise combination of the variables can be made that will represent everyone's opinion of a season's weather.

Conventional methods employed to answer this type of question usually consist of the presentation of means of temperature from year to year with a statistical test to determine whether the first portion of the record is significantly higher or lower than the last portion. Another method of attack is to study the dates of freezing and thawing of lakes or streams. The numerous variables that make up a winter's weather are naturally taken into consideration to a certain extent when this method is used. However, with the abundance of homogeneous data at hand for Blue Hill, an attempt to establish an index number for each winter appears desirable. Therefore, this study will consist of the analysis of temperature and frozen pond data in the usual way, plus an attempt to index each winter's weather with a number and then to analyze the change. The index number will be called the *winter severity index*.

The record of the Blue Hill Observatory, situated 10 miles south of Boston and 640 feet above sea level, has been selected for study. The observations are exceptional in that they have been made at a location virtually unaffected by city growth, and the temperature record is reduced to the mean of 24 hours. Also, the value for long-term trends is enhanced because the record may be extend-

Blue Hill Observatory in winter. Wintertime temperatures were obtained from the window shelter facing north on the second floor of the tower for the years through the winter of 1936-37; thereafter the shelter in the foreground was used. No significant differences in the mean temperature were caused by the change of exposure. Photograph by C. F. Brooks.

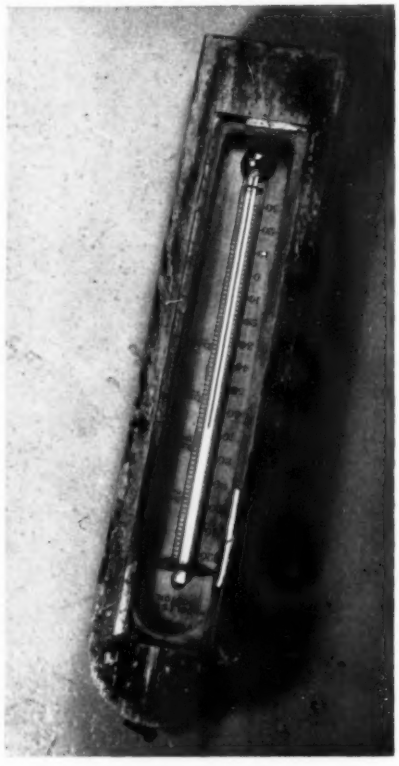
ed backward from 1885 to 1849, with a fair degree of certainty, by correcting and adjusting a record made at Milton Center, 3½ miles to the northeast.* Since the trends of annual mean temperature at Blue Hill closely parallel those at Williamstown, Massachusetts, and New Haven, Connecticut, it is apparent that the Blue Hill winter trends are representative of most of southern New England. In contrast with these stations, New Bedford, situated in southeastern Massachusetts, does not show the upward trend of annual mean temperature.

The winter-to-winter values of mean temperature, snowfall, snowcover (expressed in days with measurable snow over at least half the surface), and so forth, show so many irregularities that it is difficult to determine trends. Ten-year moving means of these elements have been computed and are shown in the chart on the facing page. From the graph of temperature it is obvious that the winter temperature (average of December, January, and February) has risen considerably in 100 years. The change is so pronounced that it is unnecessary to make a statistical test to show that the mean of the first 33 years is significantly lower than that of the last 33 years and not a chance occurrence. (Such a test when applied to the annual Blue Hill means, a plot of which is similar to the winter curve, indicated that the observed difference would be extremely unlikely to occur by chance.)

It is interesting to note that, when the temperature curve is smoothed radically by eye, a gradual rise characterizes the first decades, a more rapid rise follows, and a tapering off to approximately no change marks the last 20 years. An apparent 17-year cycle in the form of peaks of exceptionally warm winters in 1897-98, 1915-17, 1932-33, and 1949-50, cannot be taken seriously from this length of record, especially since it does not occur in the first 48 years. Furthermore, a 17-year cycle has not been detected in other parts of the world, and there is no reason to believe that one would exist only at Blue Hill.

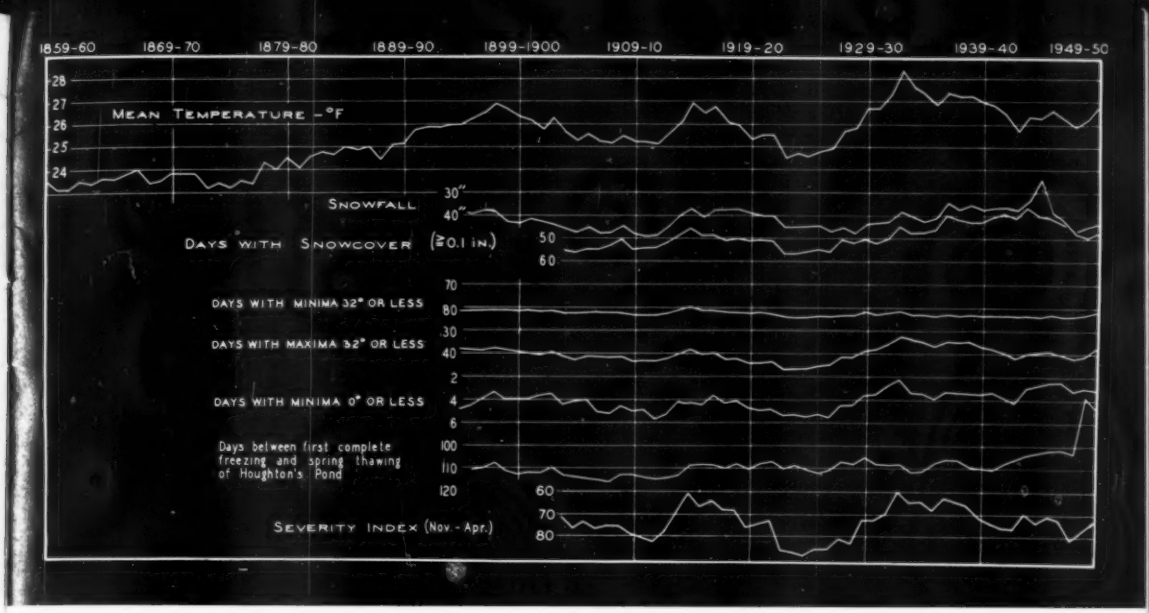
Other variables which characterize the wintriness of a season are also shown in the chart. Note that the vertical scale has been reversed from the normal in order to have the curve rise for less wintry conditions and fall for more wintry ones. For example, a greater number of days with snowcover is shown as a decline in the curve. This makes comparison with the temperature curve easier. Parallelism among the curves of mean temperature, days with snowcover, days having maxima of 32° or below, and days having minima of 0° or below, is clear.

The reason for the slight increase, during the 65 years, of days with minima 32° or below is not clear. Since only the limited season, December through February, when minimum temperatures average far below freezing, is considered, it is understandable that even a large increase in mean temperature



The thermometer used by the Reverend Charles Breck at Milton Center, Massachusetts, 1849-1888. Photograph by Al Faller.

*Details regarding the reduction of the observatory record to a mean of 24 hours and its extension back to 1849 are presented in a paper by the author, entitled "A Century of Rising Temperatures at Milton, Mass.," to be published soon.



Features of winter (December, January, February) weather at Blue Hill smoothed by 10-year moving means (plotted for the year ending). The temperature data for the years from 1849-50 to 1884-85 has been adjusted from Milton Center to Blue Hill Observatory.

could occur while the number of days with minima 32° or below remained constant. It is unlikely that the number truly increases, for the frequency of days within the other temperature limits decreases. The slight trend is probably chance and not significant.

Dates of the first freezing over and first spring thawing of two ponds near Blue Hill are also available at the observatory. Data from Houghton's Pond, which is small, quite deep, and situated one mile east-southeast of the observatory at an elevation of 170 feet, were selected for study. This pond was preferred over the other one, which is larger and shallower, because the difficulty of establishing the correct dates of freezing and thawing is less than for the larger pond. The pond's surroundings and degree of pollution have remained unchanged over the entire record.

The number of days from the date of first freezing until the thawing, for each season, have been smoothed and plotted on the chart. It is possible that the pond opened and refroze some years; hence the number of days may not equal the exact duration of the frozen condition. Note that the curve does not parallel any of the other temperature or snowfall curves very closely. If one may consider the duration from first freezing to spring thawing of pond ice a measure of a winter's severity, this indicates that the three winter months average temperature or snowfall records alone do not fully characterize a winter's weather.

Since means of wind and sunshine are not suitable for use alone as variables in the winter severity index, they must be omitted entirely from this short study. Nevertheless, it is obvious that the speed of the wind during periods of low temperature and the intensity of insolation are important factors insofar as the "feel" of the weather is concerned, and also in relation to fuel requirements.

To make up the severity index, two simple variables, the frequency of cold daytime temperature and the frequency of substantial snowcover, were chosen. The index was calculated simply by adding the number of days per season with maxima no higher than 32° to the number of days having six inches or more of snow on the ground. The latter number was obtained by counting the weeks per season that had average depths of six inches or more; this number was multiplied by 7.

Through the partial seasons (December, January, and February) the maximum temperature fails to rise above 32° on an average of 46 days, while the snowcover equals or exceeds six inches on an average of 22 days. Thus, by simply adding the two numbers to-

gether to form a severity index, the temperature factor is given about twice the weight of the snowcover factor.

The 10-year moving means of the seasonal severity index from November through April are plotted on the chart. From this curve we find that the most severe winters occurred over the periods just prior to 1911-12 and 1924-25. The individual seasonal indices show that the winter of 1922-23 was more severe than any other, with a rating of 152, while the famed winter of 1917-18 rated only 74. The latter was cold but not nearly as snowy; undoubtedly some of its reputation arises from the hardships induced by a fuel shortage and an influenza epidemic. The cold and snowy winter of 1947-48 rated 130.

MEAN TEMPERATURES AT MILTON CENTER ADJUSTED TO BLUE HILL OBSERVATORY

1849-50	26.2	1861-62	23.5	1873-74	26.0
1850-51	24.6	1862-63	26.2	1874-75	20.5
1851-52	20.0	1863-64	24.6	1875-76	26.6
1852-53	27.4	1864-65	21.6	1876-77	23.0
1853-54	22.5	1865-66	24.1	1877-78	28.0
1854-55	22.1	1866-67	23.8	1878-79	22.2
1855-56	21.8	1867-68	18.8	1879-80	30.1
1856-57	21.5	1868-69	25.4	1880-81	21.2
1857-58	25.3	1869-70	25.7	1881-82	28.0
1858-59	24.3	1870-71	24.6	1882-83	22.5
1859-60	22.6	1871-72	23.1	1883-84	25.0
1860-61	24.1	1872-73	20.5	1884-85	23.5

For those who wish to note the seasons of extremes or perform their own statistical tests the data are presented in the original form in the tables.

The following conclusions regarding the

THE CHARACTER OF EACH WINTER'S WEATHER AT BLUE HILL OBSERVATORY

Season	T	F	C	P	Max.	Min.	0°	I
1885-86	25.2	36.5			45	133	9	
1886-87	24.0	99		126	51	150	11	
1887-88	23.4	55		131	54	158	9	
1888-89	27.8	24		87	39	136	2	
1889-90	31.8	45		86	27	109	1	
1890-91	26.7	56.9		110	49	142	4	
1891-92	29.3	51.3		107	47	136	3	
1892-93	22.2	77.1		115	62	149	6	
1893-94	26.0	88.4		98	38	134	5	
1894-95	25.0	64.1	86	126	56	144	5	70
1895-96	26.4	62.0	75	117	56	137	4	77
1896-97	26.1	56.0	67	110	49	125	1	77
1897-98	28.1	75.0	67	111	39	126	4	53
1898-99	25.5	96.5	93	129	45	136	8	73
1899-00	28.5	34.0	16	100	33	135	1	33
1900-01	24.4	22.6	47	104	52	124	2	52
1901-02	26.1	55.4	55	108	36	125	0	57
1902-03	26.5	61.2	55	95	34	113	5	69
1903-04	20.5	103.4	95	127	71	153	14	141
1904-05	20.9	68.4	102	134	69	148	3	125
1905-06	29.8	46.1	52	123	34	131	2	48
1906-07	22.3	101.1	91	114	58	143	11	101
1907-08	27.6	50.4	53	117	41	140	5	41
1908-09	28.2	31.9	45	101	34	140	2	34
1909-10	26.4	59.9	54	102	42	126	5	70
1910-11	24.8	51.2	49	114	51	156	1	65
1911-12	24.9	48.0	62	115	58	132	8	72
1912-13	31.3	28.8	32	91	25	109	0	25
1913-14	26.3	58.4	65	110	45	129	4	52
1914-15	27.9	39.7	55	96	44	133	3	44
1915-16	25.4	111.5	96	119	68	136	4	107
1916-17	25.5	74.3	86	118	50	138	3	78
1917-18	20.3	67.4	87	125	67	148	11	74
1918-19	27.7	25.1	36	89	38	125	1	38
1919-20	19.8	85.3	90	123	73	144	11	143
1920-21	27.1	50.3	45	85	43	120	3	50
1921-22	25.1	53.9	69	109	47	138	7	54
1922-23	21.4	102.5	107	123	68	151	6	152
1923-24	27.9	53.6	65	95	40	124	3	61
1924-25	26.8	35.7	40	113	39	128	5	60
1925-26	27.1	57.6	79	135	46	144	2	74
1926-27	27.1	67.5	78	102	44	138	5	79
1927-28	28.4	31.2	29	92	32	135	1	32
1928-29	28.6	61.6	57	94	40	132	1	54
1929-30	28.3	34.3	55	97	38	130	2	38
1930-31	26.8	58.7	67	114	38	149	2	52
1931-32	30.8	30.5	37	111	27	122	0	27
1932-33	32.2	62.5	67	119	32	119	1	53
1933-34	21.1	71.5	94	130	56	153	13	105
1934-35	23.8	62.6	36	106	51	133	6	58
1935-36	22.1	36.8	59	99	56	126	6	105
1936-37	32.3	12.3	13	89	27	136	0	27
1937-38	27.0	54.1	54	98	37	137	1	44
1938-39	28.4	62.3	79	122	46	122	2	74
1939-40	25.0	57.9	80	102	64	150	2	92
1940-41	26.6	59.6	56	118	47	136	1	75
1941-42	26.8	39.8	27	86	35	119	4	42
1942-43	25.0	61.2	64	101	52	141	6	59
1943-44	26.5	37.7	33	109	39	132	1	39
1944-45	24.5	72.7	74	102	44	123	4	93
1945-46	24.9	91.2	64	85	50	121	3	78
1946-47	28.7	34.0	37	88	30	129	0	44
1947-48	23.4	136.0	96	111	60	162	9	130
1948-49	31.8	57.2	45	75	30	95	0	30
1949-50	30.3	48.4	55	111	27	121	5	48
Mean	25.4	58.6	62	108	46	134	4	67

In the accompanying table, the mean temperature (T) is in degrees Fahrenheit for the period December, January, and February; entire season's snowfall (F) is in inches. The number of days are given for: snowcover (C) of 0.1 inch or more over more than half the ground; frozen period (P) of Houghton's Pond; maximum temperature 32° or less; minimum 32° or less; minimum 0° or less. All these data are for the entire season; thus, the numbers do not agree in every case with the averages on the chart. The last column (I) is the winter severity index, as defined in this article.

winters of southern New England can be drawn from this brief study:

1. The overall winter (December, January, and February) temperature trend has been upward, for at least a century, although a tapering off in the rate of rise to almost no change has taken place over the last 20 years.

2. The amount of warming up in general winter temperature over the last 100-year period has been about 3½° Fahrenheit.

3. The number of snowcover days (0.1 inch or more of snow covering more than half the ground) has declined about seven days in the last 50 years.

4. The seasonal frequencies of days with maxima no higher than 32° and of days with minima 0° or below have shown similar declines.

5. The period from the first freezing until the spring thawing of Houghton's Pond has decreased approximately six days over the last 50 years.

6. The winter severity index also shows an overall decline, although there has been no pronounced trend over the last 25 years.

7. Over the 100 years of temperature record, the winter (December, January, and February) of 1867-68 was the coldest, and over the past 65 years of record the coldest was 1919-20.

The picture created from the above conclusions of continual warming, which might lead some to hope there would be no winter weather at all in the distant future, may be counterbalanced by the fact that the lowest temperature ever observed in 65 years at Blue Hill occurred only 17 years ago in February, 1934, and that the snowiest winter ever experienced in the observatory's history was that of 1947-48, only three years ago.

The author wishes to thank Miss Sarah H. Wollaston and Mr. Paul C. Dalrymple, of the observatory staff, for their help in tabulating data.

THE EFFECT OF ATOMIC BOMB EXPLOSIONS ON WEATHER

(*Continued from page 4*)

began to fall. This rainfall can be directly attributed to the widespread fires which sustained convection for a considerable time after the explosion. A similar phenomenon has been observed fairly frequently, under suitable atmospheric conditions, over large forest fires and over burning cities after bombardment.

Another very striking instance of an indirect effect of an atomic explosion on weather was the Baker Day test at Bikini. Here, as is well known, a bomb was exploded at a shallow depth in the lagoon. A gigantic wave, approximately 1,000 feet in height, was generated on the surface of the lagoon, completely surrounding the neck of many thousands of tons of ejected water and spray, as is shown in the photograph on page 3. The wave traveled speedily in all directions, maintaining an ever-expanding doughnut-shaped form. This wave has been called the *base surge*. As the surge traveled outward, it rose from the surface of the lagoon and for all practical meteorological purposes became a rather extensive stratocumulus cloud. The development of the stratocumulus cloud was accompanied by a vigorous rainfall that continued for 20 to 30 minutes.

The moist tropical air mass prevailing at the time of explosion had great thermal instability, and its moisture content was such that a 300-meter ascent would cause sufficient adiabatic cooling to cause condensation. The base surge in its initial stages acted like a front pushing the moist tropical air aloft, causing cloud and rain. Thus, here again, the atomic bomb indirectly had a local effect upon the weather.

It appears that the possibility of controlling weather by the use of atomic energy is remote. The tremendous energies required over considerable periods of time to cope with such large-scale natural phenomena as frontal storms and hurricanes are still not attainable in man-made bombs similar to those already tested.

CONTINUOUS SNOW

Snow fell for 53 consecutive days at Houghton, Michigan, during the early part of the winter. January 9, 1951, was the first day in almost two months that the weather observer did not detect at least a few flakes. Total fall so far this season reached 120 inches at the local airport, which is about 50 inches above the normal for the entire winter. Snowcover is exceptionally deep this winter on Upper Michigan's peninsula, with depths ranging from 30 to 60 inches.

During the November, 1950, storm, snow-clogged streets like this were common in cities of western Pennsylvania, Ohio, and West Virginia. This scene, looking down Webster Avenue, shows the center of Pittsburgh buried in over 31 inches of snow, as a result of the greatest storm in the city's history. Associated Press Newsphoto.

The Great Storm of November, 1950

CHARLES L. BRISTOR, SHORT-RANGE FORECAST DEVELOPMENT SECTION
UNITED STATES WEATHER BUREAU

THE STORM of November 25-26, 1950, is considered by many to be the worst on record for the eastern United States. In the Northeast it has been compared in destructive force with the great hurricanes of 1938 and 1944; in the western Appalachians it was the greatest snowstorm on record; and in parts of the Middle West and the South it was the severest early winter cold wave in history.

I. The Meteorological Events

Sustained easterly gales with hurricane gusts near 100 miles per hour along much of the northern Atlantic Coast occurred at the time of spring tide, so that flooding augmented the destructive effects of the winds. Such winds of strong or gale force also extended well inland, covering a good part of New England and eastern portions of New York State and Pennsylvania. Heavy rains (totaling more than two inches in 24 hours) accompanied the strong winds over much of this area, thus adding water damage and some flash flood destruction to the heavy toll of the winds. In New England alone nine deaths were directly related to the storm, and property damage was placed at 15 million dollars.

In the upper Ohio Valley, many stations of long record experienced new record cold temperatures for the late autumn period. Zero readings at several stations in Indiana and Ohio broke all-time low records for November. Cincinnati experienced the coldest

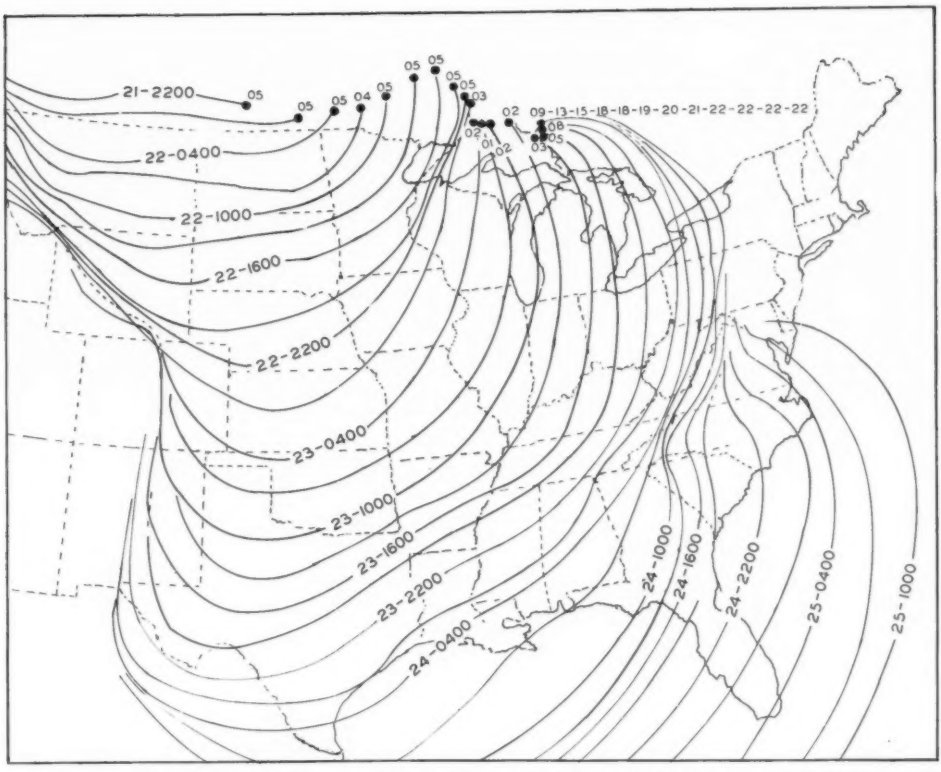


Fig. 1a. Three-hourly cold front positions beginning late on November 21st; the time is Eastern standard. The corresponding positions of the northern low pressure center are shown, together with the central pressures (beginning with 1005 millibars). Note that this center stagnated and filled by November 25th, as indicated by the three-hourly pressure values at its last position.

temperature (5°) of the entire year 1950 on November 25th. The severe cold penetrated far into the southland, with zero temperatures reaching into central Tennessee, near zero at Atlanta, Georgia, and below freezing into Florida, where Tallahassee was down to 20°.

Record heavy snows occurred at several places in eastern Ohio, western Pennsylvania, and in West Virginia. A total snowfall of 29.5 inches at Elkins, West Virginia, exceeded by nine inches that of the "greatest single storm" of November 9-11, 1913. Parkersburg reported a total of 33.3 inches, with a new 24-hour record fall of 28.3 inches. The belt of very heavy snow ran up the western slope of the Appalachian Mountains, with the industrial cities of Pittsburgh, Youngstown, and Cleveland receiving between 25 and 30 inches on the level.

At Cincinnati, on the western fringe of the

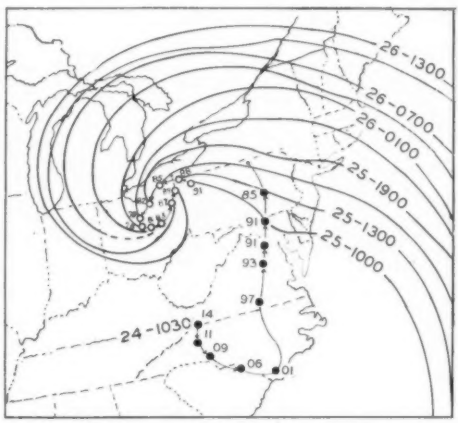
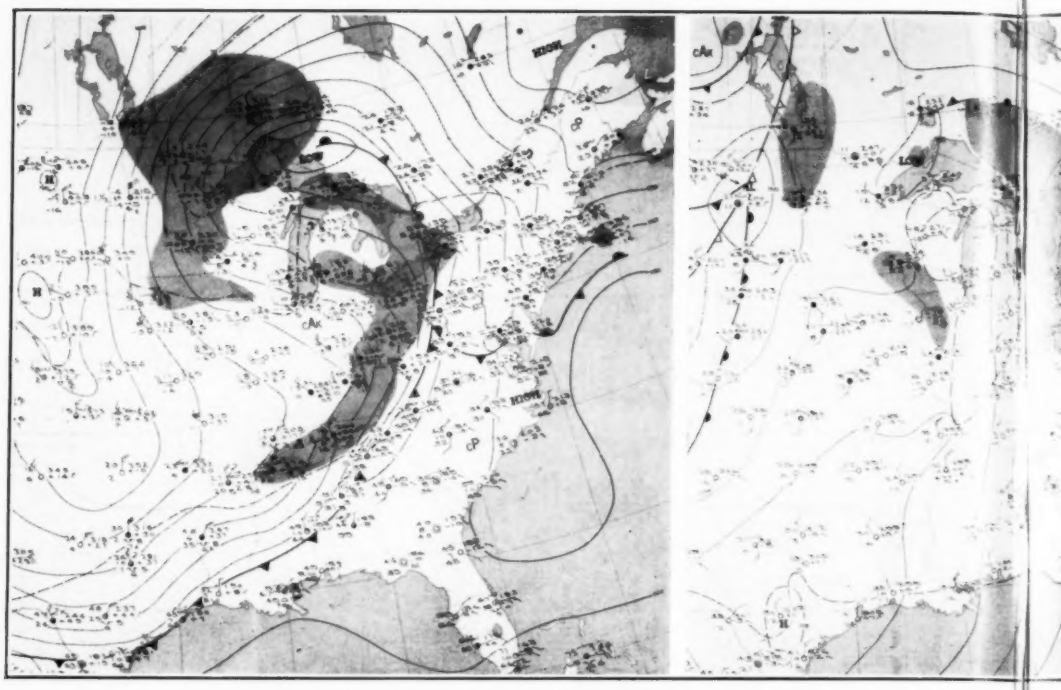


Fig. 1b. This is a continuation of Fig. 1a, beginning with its last shown front position. The deepening wave in the Southeast is marked by filled circles; that in Pennsylvania by open ones.



Figs. 2, 3, and 4. The surface charts for 1:30 a.m. Eastern standard time, November 24, 2[illegible], a[illegible]

storm. 7.8 inches of snow helped to make 1950 the wettest year of record for that station. Dayton, Ohio, with 11.2 inches of snow and strong winds with gusts to 60 miles per hour, reported the "worst blizzard" on record.

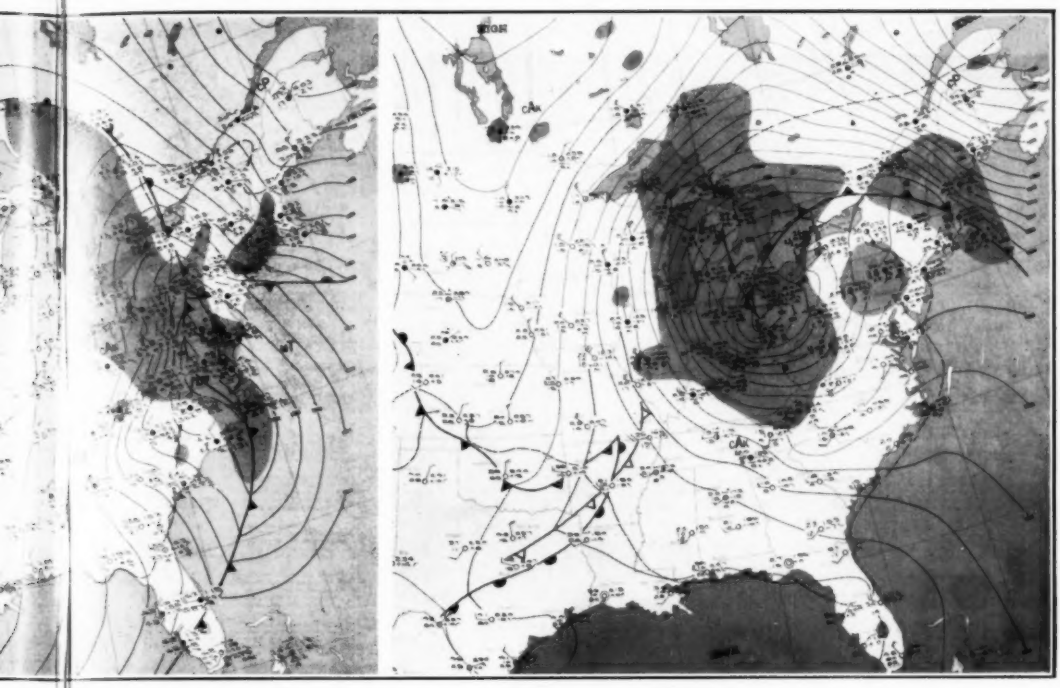
II. The Synoptic Situation

Perhaps of more interest to some amateur weathermen is the problem which this storm presented to the forecaster. This is an example of a deepening *northwestward*-moving storm that is rather infrequently observed in the United States.

The three-hourly positions of the cold front in Fig. 1 (taken from WBAN Analysis Center maps) indicate the history of the polar air mass invasion beginning on the 21st. This intense cold wave is shown as a steadily enlarging mass which gradually engulfed the entire plains area as the associated low pressure center drifted eastward above the Great Lakes. By 1:30 a.m. EST November 24th (Fig. 2) there was a slight hint of deepening in the cold frontal trough in the Alleghenies.

A few hours later there appeared more distinct signs of a wave development in the mountain ridges south of West Virginia. However, there were still no signs on the surface chart that any unorthodox development would take place. In fact not until almost 24 hours later was there significant evidence on the surface chart which pointed to an unusual situation, except perhaps the already large snow accumulation in the Pittsburgh area. By midday of the 25th, the deepening wave in the Southeast had started to recurve northward (Fig. 1b). Also the frontal trough had become greatly elongated to the north and large pressure falls were observed far to the northwest of the wave and west of the front. This was indeed a most unusual state of affairs, even for a deepening wave if it were going to move in the usual easterly direction.

Early on the 25th (Fig. 3), the evidence was borne out. Rapid deepening was taking place north of Pittsburgh, and for a time two centers existed, as can be seen in Fig. 1b. By 1:30 a.m. of the 26th (Fig. 4), the deep center



ıber 24, 25, and 26, 1950, respectively. From the Daily Weather Maps, U. S. Weather Bureau.

had become a large symmetrical vortex. Nearing a minimum pressure of 978 millibars (28.88 inches), it was describing a cyclonic track in northern Ohio. It crossed Lake Erie on the 27th and slowly filled.

III. The Forecasting Problem

This brief account of the sequence of events on the surface charts illustrates the synoptic situation which the forecaster had to predict. Of course, the construction of a completely accurate set of prognostic charts of the type commonly prepared would not guarantee the correct forecast of all weather elements. Thus far little has been done in relating prognostic charts to attendant weather elements such as precipitation and temperature changes. It may, however, be assumed that such prognostic charts would go a long way in general improvement of forecast scores, and it is therefore useful to discuss the forecast problem from this standpoint. Amateur weathermen and others not directly connected with forecasting may be interested in some of the forecast arguments, both old and new, which have been under consideration in this case.

In order that forecast arguments may be discussed, it is necessary to decide first as to when in the synoptic cycle the prediction of unorthodox development should have been made. Aside from the fact that there has always been a great need for forecasts of extended range, one might say that the correct forecast of the abnormalities in this development was needed at least at their inception if not before. From the surface charts this point seems to occur at about the time of the 0130 EST map on the 24th.

Earlier than this the cold outbreak had been moving in a fairly regular manner, and the attendant low center north of the Great Lakes had shown no discontinuity in its slow filling trend during the preceding 24 hours. Following the time of this map a portion of the cold front stagnated, and the subsequent wave formation moved in a path which cannot be extrapolated over reasonable time intervals with any degree of certainty for the remainder of the storm's history.

If this argument is accepted, one now sees

the forecaster charged with a most critical problem and at the same time stripped of a most useful tool — persistence. He had no dependable past positions of low center or isallobaric centers to extrapolate or "steer," since no marked deepening had yet occurred. There were no obvious persistent trends. However, a forecaster with experience in a certain region often uses certain "signposts" to guide him in a subjective way to the subsequent development. The active precipitation shield in eastern Ohio behind the cold front might have served in such a capacity in this instance. Also, because of the geographical peculiarities the forecaster is often aware of certain favored types of developments. Some such formations may be comparatively rare, and yet, if they represent dangerous weather situations in certain seasons, the forecaster will be alerted to their possible occurrence.

Weather patterns which occur frequently are often labeled as "types," particularly if accompanied by certain features of the pressure pattern over an appreciable area, such as the somewhat typical pattern that favors formation of Atlantic coastal waves. In a more general sense, analogous weather patterns are sometimes employed as guides in forecasting. The present case appears analogous in many respects to the famous November storm of 1913. A comparison of the two cases reveals marked similarity in the early history, new wave formations, and subsequent path of the deepening storm.* However, our lack of fundamental knowledge regarding the physical processes controlling the formation and movement of cyclones places a severe restriction upon the utilization of analogues. This ignorance precludes our knowing just what features must be similar before two synoptic situations are analogous. A "similar" case is therefore often disappointing when used as a forecast.

This discussion by no means exhausts the list of forecast arguments commonly employed by practicing forecasters. It is only stressed that, regardless of tools used, the forecaster is in a most vulnerable predicament when faced with a new synoptic development which does not yet possess measurable trends. After this stage has passed, the problem is again somewhat eased. With a deepening wave in existence, the features of the synoptic picture which are thought to exert some controlling influence can again be localized. Also, there are trends which may again be considered, to form a basis for the application of various arguments for accelerational influences. Such a stage may be taken in this case to have been at 0130 EST on the 25th (Fig. 3). Looking back, this would appear to be a rather late stage in the development from the standpoint of forecast utility. Nevertheless, even at that time forecasters were far from certain of the complete synoptic development during the next 24 hours.

IV. Forecasting Postview

Many arguments used by practicing forecasters could be introduced at this point, especially with the aid of three-dimensional analysis. C. D. Smith, in the *Monthly Weather Review* for November, 1950, discusses some concepts of mass distribution and inertia effects in connection with this storm. These ideas have received the attention of WBAN Analysis Center forecasters and show considerable promise. Pertinent also are several ideas recently considered by University of Chicago meteorologists.

These latter forecast arguments involve the high-level zone of maximum winds (jet stream) and the long-wave pattern. Some of the concepts are not new, but much additional evaluation and study are needed: application to the synoptic problem of 0130 EST, November 25, 1950, will help to illustrate the present state of these concepts. The University of Chicago and the U. S. Weather Bureau have engaged in a program of study directed toward the improvement of forecasting. The following conditions for cyclone deepening are given in an as yet unpublished report of this group:

1. In relation to the jet stream, deepening occurs within five degrees latitude of the jet, and downstream from maximum intensity, usually when the jet wind maximum is in a long-wave trough.

2. In relation to the long-wave pattern, deepening occurs at the point of strongest change from cyclonic to anticyclonic curvature, east of the trough line.

3. Deepening occurs at the lowest latitude

*The 1913 storm was described by C. P. Mook in WEATHERWISE, December, 1949, pages 126-128. Compare the synoptic charts in that article with those of this recent great November storm. — Ed.

of temperature concentration (i.e., along the front).

4. Deepening is favored in an area where some initial disturbance causes a pressure fall.

5. All of the above criteria must be present concurrently in the same location for the occurrence of deepening.

For 2200 EST on November 24th, Fig. 5 indicates the 500-mb chart and shows the position of the jet stream as expressed by the concurrent 200-mb chart.

Within the framework of these ideas this group has made the following comments in connection with the deepening November storm:

1. The cold front in the Southeast lies approximately parallel to the flow at 500 mb, and a strong horizontal temperature gradient (not shown) exists from the surface up to 500 mb or higher.

2. The surface cyclone lies under the 200-mb jet and under an area of downstream divergent 500-mb contours. It is also situated east of the deepening long-wave trough between this trough and the next downstream ridge. The jet stream wind maximum lies to the west of the surface low and near the upper-level trough.

3. Both long-wave ridges associated with the long-wave trough have intensified. This coupled with retrogression of the eastern ridge has resulted in a concentration of cyclonic vorticity in the trough.

4. It appears likely that the pressure fall noted initially in the Southeast on the 24th might be related to an earlier 12-hour pressure fall which moved southeastward into the Gulf.

Other post-mortem comments made by this group in connection with the cyclone path are that the southward shift of the zonal wind

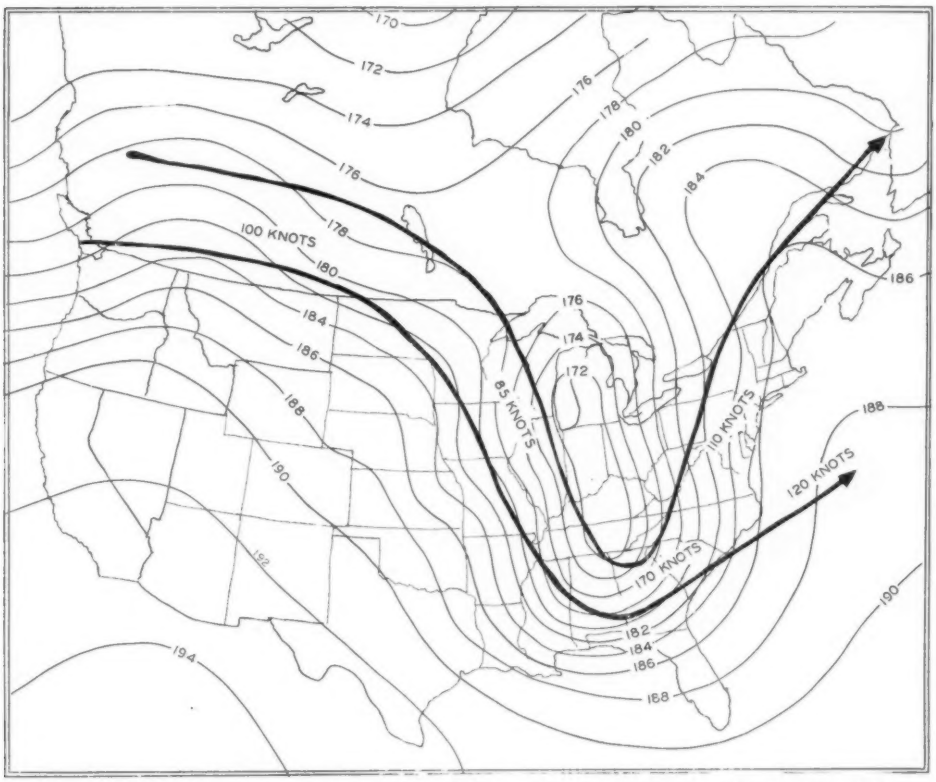


Fig. 5. The 500-mb contours and concurrent 200-mb jet stream, 10:00 p.m. EST, Nov. 24, 1950.

Heavy rainfall and winds of hurricane force marked the storm to the east and northeast of the center. Wind-driven tides did great damage along the New Jersey, Long Island, and New England coasts. This scene shows Long Island Sound invading the parking lot at LaGuardia Field, New York, where wind speeds in gusts up to 94 miles per hour were registered on the afternoon of November 25th. Wide World photograph.

maximum below its seasonal position was suggested as being influential in reorienting the upper trough line in a more NW-SE direction; the stronger west winds in the southern portion of the trough would be associated with faster eastward displacement of the trough at this latitude relative to its northern portion, thus producing a southeasterly upper flow over the cyclone; finally, that the westward movement of the ridge aloft over southeastern Canada would also be expected to augment this tendency for counterclockwise rotation of the trough line.

For some time Air Force meteorologists have also emphasized the importance of jet stream and long-wave considerations. A study of this storm conducted by members of the Weather Analysis Division, Andrews Air Force Base, stressed additional upper-air indications. An area of strong ascending motion in the 200-300-mb layer was traceable from the Dakotas to the area of the storm's development. When coupled with extreme cold advection in the lowest layers, a most favorable region of cyclogenesis was produced.

All of the above forecast arguments are presented without reference to their physical foundation. It is to be hoped, as the newer concepts become more fully developed through study and evaluation, that they will fill a much-needed position among the valuable tools available to all forecasters.

CONNECTICUT WEATHER CONTROL

On January 11th, a bill to set up a weather control commission was introduced into the Connecticut general assembly, by Representative William A. Ward, of Clinton. Authority would be vested in the state water commission to institute research and to issue licenses for rainmaking projects.

THE WEATHER CONTROL BILL

SENATOR CLINTON P. ANDERSON OF NEW MEXICO

I HAVE RECENTLY introduced a bill to provide for the development and regulation of methods of weather modification and control. To some persons this may be considered somewhat presumptuous, if not sacrilegious, as there are those who say that they are still willing to leave the weather to Divine Providence. To this I can only reply that in my judgment the sphere of Divine Providence is no more invaded by weather control than by the splitting of the atom. Occasional dramatic events, such as the recent New York water shortage, or the dust storms of a few years ago, or hurricanes or other great disturbances of nature, serve to remind us that the weather is one of the most important factors in our everyday lives. Without sufficient rainfall our agriculture is seriously affected, problems of health and adequate water supply are drastically increased. On the other hand, periods of severe storms or excessive rainfall bring devastating floods, ruin crops and take their toll in injury and damage to lives and property. The transportation of goods and persons, military problems of national defense, and, indeed, every activity in which we engage is affected directly or indirectly by the weather.

At this point, I suppose I should recognize that some will inquire, quite properly, as to the constitutional basis for this type of legislation. I do not propose to discuss that feature in detail. It will doubtless be adequately considered in committee. I want only to say that there is no doubt in my mind that this is a proper subject of federal legislation. As to specific constitutional sources of power I need only refer to the commerce clause and the war power. I call to mind in connection with the commerce clause the regulation of air navigation, water navigation (flood control and improvement of navigable waters), and radio communication. These are to me convincing considerations, leaving aside the interstate movement of the clouds themselves, and are sufficient to justify federal legislation by specific reference to the clause itself or under the necessary and proper clause. With regard to the war power, the analogy to atomic energy is plain and to my mind equally as potent. It was General Kenny who said, "The nation which first learns to plot the paths of air masses accurately and learns to control the time and place of precipitation will dominate the globe."

The bill in general follows the outline of the Atomic Energy Act of 1946, that is, it in effect places weather modification and control activities exclusively under the control of the federal government. I recognize that there are competent and well-meaning persons both within and without the government who take the position that regulation in this field is premature, and that we have not yet gained the knowledge upon which to base comprehensive legislative regulation. Equally competent persons take the opposite view, and point out that while it is a field in which unknown factors are involved, the implications are so great that it is better now to seek the application of measures with proper safeguards. With this latter group I agree. I am not so sure that from a scientific standpoint it is not just as important to deal with this subject now as it was to deal with atomic energy at the time of the enactment of the Atomic Energy Act of 1946. It is probable that economic benefits may be realized much sooner than in the case of atomic energy. I am not so sure, either, that weather modification and control is not closely related, at least from the standpoint of national security, to the utilization of atomic energy as a military weapon. In any event, I am convinced that an attempt to set up intelligent regulation should be made immediately, even though it will necessarily be subject to revision from time to time as the results of weather control measures become more predictable. To my mind it is a question of intelligent regulation now or continued haphazard interference with the weather with no central authority to channel the course of these measures in the national interest.

When it is considered that the potentialities

Senator Clinton P. Anderson, of New Mexico, sponsor of the weather control bill, is a member of the Senate committee on agriculture and forestry.

in this field go all the way from inducing, increasing, or preventing precipitation, to changing the course, or modifying the intensity, of a thunderstorm or a hurricane, the almost terrifying implications seem to me to make it obvious that the federal government should occupy this field now. While research and experimentation in the field of weather modification and control have attained the stage at which the application of scientific advances in this field has practical significance, the effect of the use of such measures upon the social, economic and political structures of our country and upon national security is yet to be determined. This is a field in which uncommon factors and unsolved problems are involved. As stated in the bill which I have introduced, it is reasonable to anticipate, however, that effective modification and control of the weather will cause or produce profound changes in our present way of life and will result in far-reaching benefits to and untold developments in agriculture, industry, commerce and the general welfare. While the ultimate extent to which measures for weather control may be utilized is still speculative, the application of such measures without proper safeguards, sufficient data, and accurate information, may result in inadequate or excessive precipitation; may cause catastrophic droughts, storms, floods and other phenomena with consequent loss of life and property, injury to navigable streams and other channels of interstate and foreign commerce, injury to water supplies for municipal, irrigation, and industrial purposes, and injury to sources of hydroelectric power. Such measures, improperly applied, may also impede the production and transportation of goods and services for domestic consumption and export, may impair or hinder the national defense, and in many other ways may adversely affect the general welfare of the people of the United States. Moreover, thorough experimentation in, and application of, such measures will of necessity affect areas extending across state and even international boundaries.

Accordingly, it seems clear that further experimentation in and application of measures for weather control are matters of national concern which can not and should not be left to haphazard and undirected private and individual action, uncontrolled by any responsible body and without any comprehensive planning for uniform and beneficial development. Believing that the time has come for definite action to correct this situation I have introduced S. 222, the purpose of which is to insure that maximum benefits may result from weather modification and control; to regulate and supervise all those who attempt to engage in such activity; to correlate and evaluate the information derived from such activity; and to achieve co-operation with the several states and the duly authorized officials thereof concerning such activity, all to the end of encouraging the intelligent and beneficial development of weather modification and control, preventing its harmful and indiscriminate exercise and fostering sound economic conditions in the public interest.

To achieve these purposes the bill provides for four major programs relating to weather modification or control:

1. A program of assisting and fostering private research and development to encourage maximum scientific progress.

2. A program of federally conducted research and development to assure the government of adequate scientific and technical accomplishment.

3. A program for government control of experiments and operations in order to advance the general welfare, assure the common defense and national security, and to promote the broadest possible exploitation of the field.

4. A program of administration which will be consistent with the foregoing policies and with international arrangements made by the United States, and which will enable the Congress to be currently informed so as to take further legislative action as may hereafter be appropriate.

S. 222 SECTION-BY-SECTION ANALYSIS

Section 1 provides a short title, the "Weather Control Act of 1951."

Section 2 embodies the declaration of policy, consisting of a statement of findings and a declaration, and a brief outline of the purpose of the Act.

Section 3 provides for the organization of a Weather Control Commission to administer the Act, and provides for a general civilian advisory committee, a military liaison committee, and an interdepartmental advisory board, to advise the Commission in the several phases of its operations.

Section 4 provides for assistance to private or public institutions or persons in the field of weather modification and control, and also authorizes the Commission to engage in activities in such field.

Section 5 provides for military applications of weather modification and control and includes authority in the Commission to conduct experiments and do research and development work in this field, and also authorizes the President to direct the Commission to authorize the armed forces to engage in activities for weather modification and control as a military operation.

Section 6 provides for the issuance of licenses to engage in activities for weather modification and control. In general no person may engage in such activities without a license issued by the Commission. In connection with the issuance of licenses the Commission may provide for the regulation of rates, fees and charges for carrying out weather modification and control projects on a commercial basis. The Commission is also authorized to provide by regulation

for exempting from the licensing requirements laboratory research and experiments and activities of an emergent character for protection against frost, ice, or fog. A typical example of the latter would be the well-known smudge pots to protect fruit trees against frost.

Section 7 recognizes the serious international implications of weather modification and control and in general provides for the subordination of domestic measures to international arrangements.

Section 8 outlines the general authority of the Commission, including the authority to establish advisory boards and the regulatory authority, and outlines the administrative powers of the Commission.

DROUGHT IN THE SOUTHWEST

From southern California to Texas, the Southwest is in the grip of a severe drought of several months duration. In northern Arizona a third of the cattle have been shipped out to market or to other pastures, for feed has been increasingly sparse. The Flagstaff Weather Bureau reported that only 10.48 inches of rain fell in 1950, about half the normal amount.

In New Mexico the water shortage is almost as acute as last summer's, and dust bowl conditions are again threatening this area. It has been very dry for over three months. The last appreciable rainfall in 1950 at Albuquerque was on September 30th, and the rainfall for the year totaled only 4.1 inches, about half the normal, making it the third driest year since records commenced in 1892.

Southern California reckons itself more than two years behind in rainfall, and counts its drought as starting in 1944. Since then, the aggregated deficiency has totaled 36 inches — the normal rainfall for twenty-eight months — despite many rain-increasing projects throughout the area. The rainmakers find they can make no rain if there are no natural clouds.

FLORIDA STATE GRADUATE COURSES

Florida State University has announced the availability of graduate assistantships, carrying a stipend of $125 per month, for graduate study in meteorology and climatology. Appointments will be made in connection with research projects being conducted for the Office of Naval Research and the Air Materiel Command, U. S. Air Force. The student is excused from payment of the out-of-state tuition fee and is permitted to carry as many as 10 hours of course work.

Minimum requirement for consideration is a bachelor's degree from an accredited institution, with two years of university mathematics and one year of university physics. Applications should be filed before May 1, 1951, but late applicants will be considered if vacancies remain. Application forms and information may be obtained from the Dean of the Graduate School, Florida State University, Tallahassee, Florida.

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STAMFORD WEATHER CENTRAL

A WEATHER CENTRAL was recently established at the Stamford Museum, and it has already proven of great value to Stamford and surrounding communities in southwestern Connecticut. During the great windstorm of November 25, 1950, the weather central remained open until late in the evening when the high winds had subsided. A special radio broadcast was made to relay the information to the public that the worst of the blow was over.

The basic task of the weather central is to maintain accurate records of the weather for the Stamford area. Records are kept both at the museum and at several outlying points where the temperature differs markedly from the museum area. The installation at the museum has been designated a co-operative station of the U.S. Weather Bureau, and thus been given official status as an observing point.

A second activity of great value to the community is the broadcast from 8:15 to 8:20 a.m., six days a week over radio stations WSTC (1400 kilocycles) and WSTC-FM (96.7 megacycles). A full summary of local conditions, a relay of airways weather reports from the entire Northeast, and a weather outlook for the next two days make up the main portion of the broadcast. Local driving condition reports and a "clothesline forecast" have proven popular items with the local audience. In the summer, special wind expectations are relayed for the yachting fans on nearby Long Island Sound.

The Stamford Museum Weather Club was organized in November, 1950. Among the 25 members are many who were original members of the Amateur Weathermen of America. Recently the club was addressed by James McGuire, climatologist at the New York Weather Bureau, who gave a talk, "The Great Storm of November 25, 1950."

The Stamford weather center looks forward to participating in all phases of the national defense program. Classes are planned to assist those who wish to study meteorology before entering the armed services, and liaison has been set up with the local civil defense authorities to supply weather reports.

At their weather station in the Stamford Museum, weathermen Robert E. Cox (left) and Ernest Ludhe, director of the museum, plan their daily radio broadcast to Stamford and surrounding communities. Photograph by Arnold Walter.

AMERICAN METEOROLOGICAL SOCIETY 108th MEETING

EARLY IN DECEMBER, the American Meteorological Society held its 108th national meeting at Florida State University, Tallahassee. Abstracts of some of the papers of general interest are presented here.

The interrelationship of atmospheric circulations having different periods of evolution was discussed by Jerome Namias, USWB. By means of the simple smoothing process of constructing mean maps for mid-tropospheric levels for various intervals of time, singular features of circulation appear which possess logical continuity from period to period, providing the length of period is the same. The dimensions of circulations appear to grow larger and their rate of evolution and movement smaller as the period over which the averaging is performed increases.

As this period becomes shorter, however, the individual elements of circulation appear to behave as though governed by the longer period and the phenomena of larger scale — features that represent the upper-air components of the great centers of action. The importance of these empirical results lies in their adaptation to all forms of weather forecasting, short and long range, through a deductive as opposed to the customary inductive method of approach.

Irving I. Gringorten, of the Air Force Cambridge Research Laboratories, has considered the basis to be used for the verification and scoring of weather forecasts. In scoring a forecast, one of two purposes should be considered: either to determine the utility of the forecast or to determine the skill of the forecaster. If the purpose is utility, then the score for each forecast should be directly proportional to the value of the forecast in meeting specified operational requirements. If the skill is the purpose, then the total score for a series of forecasts should be a reflection of the forecaster's ability to recognize the sign and magnitude of the departure of the weather conditions from the average.

Special instruments have been developed to locate and track meteorological phenomena characterized by associated lightning activity. These were described by W. F. Zetrouer and W. J. Kessler, of the University of Florida. Basically, the instruments are radio receivers of special design operating in the extremely low-frequency portion of the electromagnetic spectrum which provide visual displays of the raucous sounds commonly referred to as radio static.

An instantaneous atmospheric (sferics) direction finder displays the directions of ar-

Some of the weather experts who attended the meeting at Florida State University were, left to right: D. M. Little, assistant chief of the U. S. Weather Bureau, Washington, D. C.; R. G. Stone, Air Weather Service; J. J. George, Eastern Air Lines; Horace R. Byers, University of Chicago; P. E. Church, University of Washington; Kenneth C. Spengler, executive secretary, American Meteorological Society; and Werner A. Baum, Florida State University, general chairman of the meeting.

rival of lightning radiations on the screen of a cathode-ray tube of the type employed in television receivers; associated with this is equipment providing for the instantaneous telemetering of the data over a conventional radio link to any central point for triangulation purposes. There is also an atmospherics wave-form receiver that provides a visual record of the instantaneous time variation of the intensity of the electromagnetic radiations from individual lightning discharges.

The Florida scientists also described such Lugeon instruments as the radiogoniograph, which provides a statistical record of the atmospherics activity in azimuth (direction) and time; the radiomaxigraph, recording peak intensity against time; and the atmoradiograph, which records the frequency of lightning discharges.

Mr. Kessler and associates C. Y. Goyder and D. C. Bunting described electrical activity associated with three hurricanes as measured by some of the instruments mentioned above. Combined weather, radar, and electrical charts reveal that in each case the lightning radiations from the center or eye of the hurricane are negligible. These results are substantially in agreement with the early work of Sashoff and Weil using instantaneous radio direction finders.

An apparatus has been developed for the measurement of very small variations in air density. It was described by Guenter Schwarz, George L. Rogosa, and Werner A. Baum, of Florida State University. It is based on the scattering of alpha particles (helium nuclei) depending on the temperature and the water-vapor content of the air. Measurements of the vertical gradients of these two factors in the air near the surface of the earth (microclimatic layer) is particularly difficult.

The source of the alpha particles is a layer of the element polonium deposited on a flat nickel sheet. The alphas are detected by a thin-window Geiger counter, operating in conjunction with a counting-rate meter and a graphic recorder. Changes in the recorded intensity can be related to the density of the gas between the source and the detector. Preliminary experiments indicate that variations of a small fraction of one per cent in the density of the air may be measured.

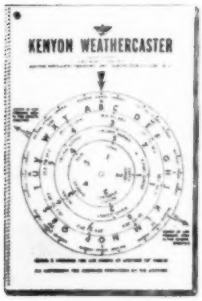
An example of the importance of weather in public health was discussed by Harold S. Lippmann, USWB, who has computed from clinical data over 16½ years the monthly rate of incidence of miliaria rubra (prickly heat) in the city of Miami, Florida. It is suggested that the rate is exponentially related to the mean monthly temperature, the mean monthly dewpoint temperature, and the mean monthly wind speed for the city. This hypothesis was tested against the data, and the index of correlation was computed to be 0.96.

With the increasing number of rawin stations, direct analysis of the upper wind field on a regular day-to-day basis may soon be possible. Arthur F. Gustafson, Air Weather Service, described the manner in which the wind field for a given level can be represented by streamlines and isotachs (lines of constant wind speed). Analyses of the wind speed fields (isotach analyses) for several map series have shown that isotach patterns can be recognized from day to day, and that they move with their associated pressure-height patterns. An example of a series of isotach charts for 30,000 feet was shown, together with the corresponding 300-mb contour charts. Short-range forecasting of the high-level wind speeds by direct time extrapolation of isotach patterns, without recourse to an intermediary pressure field forecast, appears quite feasible.

The weather on other planets is coming in for its share of attention, chiefly as a result of observations made at the Lowell Observatory, Flagstaff, Arizona, and the analyses of Mars and Jupiter made by Seymour L. Hess, now of Florida State University. Recently, Mr. Hess has shown that the circulation and cloud phenomena of Mars bear close resemblance to what we should expect in an atmosphere similar in some characteristics to the earth's. Now he describes his studies of Jupiter, a planet noted for the pronounced vari-colored belts and zones that extend around it parallel to its equator of rotation.

A recent attempt by Schoenberg to explain the observed circulation on Jupiter has been examined by Mr. Hess and found to be inadequate. He has attempted a semi-empirical approach from the point of view of large-scale, horizontal mixing, with the result that the equatorial regions are found to be marked by a nearly constant rate of transport of vorticity across latitude circles, while the rest of the planet exhibits nearly solid rotation.

Forecasting Aids



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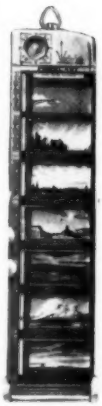

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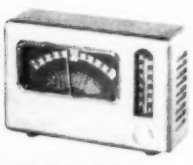

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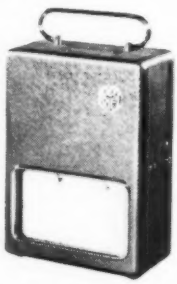

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